CLAIMS

What is claimed is:

1. An electrochemical device, comprising:

(A) a first electrochemical reactor that includes:

(a) a single or multiple electrochemical cells, each of the cells including:

an anode compartment, including a first gas inlet, an anode and a first gas outlet;

a cathode compartment, including a second gas inlet, a cathode and a second gas outlet; and

an ion-selective partition between the anode and cathode;

(b) a first gas inlet and outlet in fluid communication with the anode compartment of each of the cells;

(c) a second gas inlet and outlet in fluid communication with the cathode compartment of each of the cells; and

(d) a galvanostat in electrical communication with the anode and cathode of each of the electrochemical cells; and

(B) a gas source in fluid communication with the anode compartment or cathode compartment of each of the electrochemical cells, including at least two components that are selectively reactive relative to each other, the selectivity being dependent upon an electrical potential between the anode and cathode, whereby a constant current between the anode and cathode causes the electrical potential to oscillate autonomously while the gas components are directed through said anode compartment or cathode compartment, the oscillation in potential causing autonomous oscillation of selective reaction of the gas components, and

(C) a fuel cell system that includes a single fuel cell or a stack of fuel cells, each of the fuel cells including an anode compartment, a cathode compartment and a proton-exchange membrane between the anode and cathode compartments, wherein the first or second gas outlet of the electrochemical device is in fluid communication with the fuel cell system.

2. The device of Claim 1, wherein the gas source is in fluid communication with the anode compartment of each of the electrochemical cells.

3. The device of Claim 2, wherein the first gas outlet of the electrochemical device is in fluid communication with the anode compartment of the fuel cell system.

4. The device of Claim 3, wherein the gas source includes carbon monoxide.

5. The device of Claim 4, wherein the gas source includes carbon monoxide in a concentration at least 50 ppm.

6 The device of Claim 4, wherein the fuel cell is selected from the group consisting of a proton-exchange membrane fuel cell, a phosphoric acid fuel cell, an alkaline fuel cell, a molten carbonate fuel cell and a solid oxide fuel cell.

7. The device of Claim 6, wherein the ion-selective partition of each of the electrochemical cells independently is selected from a proton-exchange membrane, a hydroxide solution, phosphoric acid, molten carbonate and a solid oxide.

8. The device of Claim 7, wherein the gas source is a CO-containing, hydrogen-rich reformate source.

9. The device of Claim 8, wherein the fuel cells are a proton-exchange membrane fuel cell.

10. The device of Claim 9, wherein the ion-selective partition is a proton-exchange membrane.

11. The device of Claim 10, the anode and cathode of each of the electrochemical cells are each independently a gas diffusion electrode.

12. The device of Claim 11, the gas diffusion electrodes for the anode and cathode each independently comprise a catalyst that includes at least one element selected from the group consisting of Pt, Ru, Pd, Rh, Ir, Fe, Co, Cr, Cu, Ag, Ni, Mo and Au.

13. The device of Claim 12, wherein each of the catalysts for the anode and cathode independently further includes at least one element selected from the group consisting of carbon black, Al_2O_3, an oxide of manganese, an oxide of cobalt, an oxide of nickel, AgO or a mixture thereof.

14. The device of Claim 12, wherein the proton-exchange membrane includes a solid polymer.

15. The device of Claim 14, wherein the solid polymer is selected from the group consisting of a perfluorinated ionomer, polybenzimidazole and sulfonated polyether ether ketone.

16. The device of Claim 15, wherein the solid polymer is a perfluorinated ionomer, reinforced with poly(tetrafluoroethylene).

17. The device of Claim 14, wherein the galvanostat is set at a value in a range of between about 30 mA/cm^2 and about 700 mA/cm^2.

18. The device of Claim 14, further including a CO and/or CO_2 gas analyzer in fluid communication with the first gas outlet of the electrochemical reactor.

19. The device of Claim 18, further including a rechargeable battery connected to the reactor, whereby power output of the reactor is stored in the battery.

20. The device of Claim 18, wherein the power output of the electrochemical reactor is integrated into the power output of the fuel cell system.

21. The device of Claim 9, further including a second electrochemical reactor that includes:

    (a) a single or multiple electrochemical cells, each of the cells including:

        an anode compartment, including a first gas inlet, an anode and a first gas outlet;

        a cathode compartment, including a second gas inlet, a cathode and a second gas outlet; and

        an ion-selective partition between the anode and cathode;

    (b) a first gas inlet and outlet in fluid communication with the anode compartment of each of the cells;

    (c) a second gas inlet and outlet in fluid communication with the cathode compartment of each of the cells; and

    (d) a galvanostat in electrical communication with the anode and cathode of each of the electrochemical cells,

    wherein the first gas outlet of the first electrochemical reactor is in fluid communication with the first gas inlet of the second electrochemical reactor, and wherein the first gas outlet of the second electrochemical reactor is in fluid communication with the anode compartment of the fuel cell system.

22. The device of Claim 21, wherein the ion-selective partition of each of the electrochemical cells in the second electrochemical reactor is selected from a proton-exchange membrane, a hydroxide solution, phosphoric acid, molten carbonate and solid oxide.

23. The device of Claim 22, wherein the ion-selective partition of each of the electrochemical cells in the second electrochemical reactor is a proton-exchange membrane.

24. The device of Claim 23, the anode and cathode of each of the electrochemical cells in the second electrochemical reactor is a gas diffusion electrode.

25. The device of Claim 24, the gas diffusion electrodes for the anode and cathode each independently comprise a catalyst that includes at least one element selected from the group consisting of Pt, Ru, Pd, Rh, Ir, Fe, Co, Cr, Cu, Ag, Ni, Mo and Au.

26. The device of Claim 25, wherein the galvanostat of the second electrochemical reactor is set at a value in a range of between about 30 mA/cm^2 and about 700 mA/cm^2.

27. The device of Claim 25, further including a CO and/or CO_2 gas analyzer in fluid communication with the first gas outlet of the second reactor.

28. The device of Claim 26, further including a rechargeable battery connected to the first and second reactors, whereby power output of the reactors is stored in the battery.

29. The device of Claim 26, wherein the power output of the electrochemical reactors is integrated into the power output of the fuel cell system.

30. A method of purifying a gas, comprising the step of:

directing the gas from a gas source through an anode compartment or cathode compartment of an electrochemical reactor, wherein the electrochemical reactor further includes:

an ion-selective partition between the anode compartment and cathode compartment; and

a galvanostat in electrical communication with an anode of the anode compartment and a cathode of the cathode compartment,

and wherein the gas includes at least two components that are selectively reactive relative to each other, the selectivity being dependent upon an electrical potential between the anode and cathode, whereby a constant current between the anode and cathode causes the electrical potential to oscillate autonomously while the gas is directed through the anode compartment or cathode compartment, the oscillation in potential causing autonomous oscillation of selective reaction of the gas components that predominantly removes one of the two components, thereby purifying the gas; and

directing the purified gas through an anode compartment or a cathode compartment of a fuel cell system that includes a single fuel cell or a stack of fuel cells.

31. The method of Claim 30, wherein the gas is directed through the anode compartment of the electrochemical reactor.

32. The method of Claim 31, wherein the purified gas is directed through the anode compartment of the fuel cell system.

33. The method of Claim 32, wherein the gas source includes carbon monoxide.

34. The method of Claim 33, wherein the gas source includes carbon monoxide in a concentration at least 50 ppm.

35. The method of Claim 33, wherein the fuel cell is selected from the group consisting of a proton-exchange membrane fuel cell, a phosphoric acid fuel cell, an alkaline fuel cell, a molten carbonate fuel cell and a solid oxide fuel cell.

36. The method of Claim 35, wherein the ion-selective partition of the electrochemical reactor is selected from a proton-exchange membrane, a hydroxide solution, phosphoric acid, molten carbonate and solid oxide.

37. The method of Claim 36, wherein the gas is a CO-containing, hydrogen-rich reformate.

38. The method of Claim 37, wherein carbon monoxide is selectively removed from the reformate.

39. The method of Claim 38, wherein the fuel cell is a proton-exchange membrane fuel cell.

40. The method of Claim 39, the anode and cathode of the electrochemical reactor are each independently a gas diffusion electrode.

41. The method of Claim 40, wherein the gas diffusion electrodes for the anode and cathode of the reactor each independently comprises a catalyst

that includes at least one element selected from the group consisting of Pt, Ru, Pd, Rh, Ir, Fe, Co, Cr, Cu, Ag, Ni, Mo and Au.

42. The method of Claim 41, wherein each of the catalysts for the anode and cathode independently further includes at least one element selected from the group consisting of carbon black, Al_2O_3, an oxide of manganese, an oxide of cobalt, an oxide of nickel, AgO or a mixture thereof.

43. The method of Claim 42, wherein the proton-selective partition is a proton-exchange membrane.

44. The method of Claim 43, wherein the proton-exchange membrane includes a solid polymer.

45. The method of Claim 44, wherein the solid polymer is selected from the group consisting of a perfluorinated ionomer, polybenzimidazole and sulfonated polyether ether ketone.

46. The method of Claim 44, the gas is directed through the anode compartment at a temperature in a range of between about 10 °C and about 80 °C.

47. The method of Claim 44, wherein the galvanostat is set at a value in a range of between about 30 mA/cm^2 and about 700 mA/cm^2.

48. The method of Claim 45, wherein the solid polymer is a perfluorinated ionomer, reinforced with poly(tetrafluoroethylene).

49. A method of purifying a gas that includes CO and hydrogen, comprising the step of:

directing the gas from a gas source through an anode compartment of an electrochemical reactor, wherein the electrochemical reactor further includes:

an ion-selective partition between the anode compartment and cathode compartment; and

a galvanostat in electrical communication with an anode of the anode compartment and a cathode of the cathode compartment,

and wherein selectivity of reaction of CO and hydrogen at the anode compartment is dependent upon an electrical potential between the anode and cathode, whereby a constant current between the anode and cathode causes the electrical potential to oscillate autonomously while the gas is directed through the anode compartment, the oscillation in potential causing autonomous oscillation of selective reaction of CO and hydrogen that predominantly removes CO, thereby purifying the gas.